IN THE CLAIMS

Please amend claims 1, 2, 4, 17 and 20, and add claims 21-25 as follows:

1. (Currently Amended) A linear method for performing head motion estimation from facial feature data, the method comprising the steps of:

obtaining a first facial image and detecting a head in said first image;

detecting position of not more than four points P of said first facial image where $P = \{\mathbf{p}_1, \mathbf{p}_2, \mathbf{p}_3, \mathbf{p}_4\}$, and $\mathbf{p}_k = (x_k, y_k)$;

obtaining a second facial image and detecting a head in said second image;

detecting position of not more than four points P' of said first facial image where $P' = \{\mathbf{p}'_1, \mathbf{p}'_2, \mathbf{p}'_3, \mathbf{p}'_4\}$ and $\mathbf{p}'_k = (x'_k, y'_k)$~~)~~; and~~,~~

determining the motion of the head represented by a rotation matrix R and translation vector T using said points P and P'.

2. (Currently Amended) The linear method of claim 1, wherein said four points P of said first facial image and said four points

P' of said second facial image include locations of outer corners of each eye and mouth of each respective first and second facial images.

3. (Original) The linear method of claim 1, wherein said head motion estimation is governed according to:

$\mathbf{P}'_i = R\mathbf{P}_i + \mathbf{T}$, where $R = \begin{bmatrix}\mathbf{r}_1^T \\ \mathbf{r}_2^T \\ \mathbf{r}_3^T\end{bmatrix} = \left[r_{ij}\right]_{3\times 3}$ and $\mathbf{T} = \left[T_1 \quad T_2 \quad T_3\right]^T$ represent camera rotation and translation respectively, said head pose estimation being a specific instance of head motion estimation.

4. (Currently Amended) ~~The linear method of claim 3~~ A linear method for performing head motion estimation from facial feature data, the method comprising the steps of:

obtaining a first facial image and detecting a head in said first image;

detecting position of four points P of said first facial image where $P = \{\mathbf{p}_1, \mathbf{p}_2, \mathbf{p}_3, \mathbf{p}_4\}$, and $\mathbf{p}_k = (x_k, y_k)$;

obtaining a second facial image and detecting a head in said second image;

detecting position of four points P' of said first facial image where $P' = \{\mathbf{p}'_1, \mathbf{p}'_2, \mathbf{p}'_3, \mathbf{p}'_4\}$ and $\mathbf{p}'_k = (x'_k, y'_k)$) ; and,

determining the motion of the head represented by a rotation matrix R and translation vector T using said points P and P',

wherein said head motion estimation is governed according to:

$\mathbf{P}'_i = R\mathbf{P}_i + \mathbf{T}$, where $R = \begin{bmatrix} \mathbf{r}_1^T \\ \mathbf{r}_2^T \\ \mathbf{r}_3^T \end{bmatrix} = [r_{ij}]_{3\times3}$ and $\mathbf{T} = [T_1 \quad T_2 \quad T_3]^T$ represent camera rotation and translation respectively, said head pose estimation being a specific instance of head motion estimation, and

wherein said head motion estimation is governed according to said rotation matrix R, said method further comprising the steps of:

determining rotation matrix R that maps points $\mathbf{P}_k$ to $\mathbf{F}_k$ for characterizing a head pose, said points $\mathbf{F}_1, \mathbf{F}_2, \mathbf{F}_3, \mathbf{F}_4$ representing three-dimensional (3-D) coordinates of the respective four points of a reference, frontal view of said facial image, and $\mathbf{P}_k$ is the three-dimensional (3-D) coordinates of an arbitrary point where $\mathbf{P}_i = [X_i \quad Y_i \quad Z_i]^T$, said mapping governed according to the relation:

$$R(\mathbf{P}_2 - \mathbf{P}_1) \propto [1 \quad 0 \quad 0]^T$$
$$R(\mathbf{P}_6 - \mathbf{P}_5) \propto [0 \quad 1 \quad 0]^T$$

wherein P_5 and P_6 are midpoints of respective line segments connecting points P_1P_2 and P_3P_4 and, line segment connecting points P_1P_2 is orthogonal to a line segment connecting points P_5P_6, and $\propto$ indicates a proportionality factor.

5. (Original) The linear method of claim 4, wherein components r1, r2 and r3 are computed as:

$$\mathbf{r}_2^T(\mathbf{P}_2 - \mathbf{P}_1) = 0$$
$$\mathbf{r}_3^T(\mathbf{P}_2 - \mathbf{P}_1) = 0$$
$$\mathbf{r}_1^T(\mathbf{P}_6 - \mathbf{P}_5) = 0$$
$$\mathbf{r}_3^T(\mathbf{P}_6 - \mathbf{P}_5) = 0$$

6. (Original) The linear method of claim 5, wherein components r1, r2 and r3 are computed as:

$$\mathbf{r}_3 = (\mathbf{P}_6 - \mathbf{P}_5) \times (\mathbf{P}_2 - \mathbf{P}_1),$$

$$\mathbf{r}_2 = \mathbf{r}_3 \times (\mathbf{P}_2 - \mathbf{P}_1)$$
$$\mathbf{r}_1 = \mathbf{r}_2 \times \mathbf{r}_3$$

7. (Original) The linear method of claim 4, wherein

$$\begin{bmatrix} \mathbf{P}_i^T & \mathbf{0}^T & \mathbf{0}^T & 1 & 0 & 0 \\ \mathbf{0}^T & \mathbf{P}_i^T & \mathbf{0}^T & 0 & 1 & 0 \\ \mathbf{0}^T & \mathbf{0}^T & \mathbf{P}_i^T & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \mathbf{r}_1 \\ \mathbf{r}_2 \\ \mathbf{r}_3 \\ \mathbf{T} \end{bmatrix} = \mathbf{P}_i' ,$$

each point pair yielding 3 equations, whereby at least four point pairs are necessary to linearly solve for said rotation and translation.

8. (Original) The linear method of claim 7, further comprising the step of: decomposing said rotation matrix R using Singular Value Decomposition (SVD) to obtain a form $R = USV^T$.

9. (Original) The linear method of claim 7, further comprising the step of computing a new rotation matrix according to $R = UV^T$.

10. (Original) A linear method for performing head motion estimation from facial feature data, the method comprising the steps of:

obtaining image position of four points $\mathbf{P}_k$ of a facial image;

determining a rotation matrix R that maps points $\mathbf{P}_k$ to $\mathbf{F}_k$ for characterizing a head pose, said points $\mathbf{F}_1, \mathbf{F}_2, \mathbf{F}_3, \mathbf{F}_4$ representing three-dimensional (3-D) coordinates of the respective four points of a reference, frontal view of said facial image, and $\mathbf{P}_k$ is the three-dimensional (3-D) coordinates of an arbitrary point where $\mathbf{P}_i = [X_i \quad Y_i \quad Z_i]^T$, said mapping governed according to the relation:

$$R(\mathbf{P}_2 - \mathbf{P}_1) \propto [1 \quad 0 \quad 0]^T$$
$$R(\mathbf{P}_6 - \mathbf{P}_5) \propto [0 \quad 1 \quad 0]^T$$

wherein P_5 and P_6 are midpoints of respective line segments connecting points P_1P_2 and P_3P_4 and, line segment connecting points P_1P_2 is orthogonal to a line segment connecting points P_5P_6, and $\propto$ indicates a proportionality factor.

11. (Original) The linear method of claim 10, wherein components r1, r2 and r3 are computed as:

$$\mathbf{r}_2^T(\mathbf{P}_2 - \mathbf{P}_1) = 0$$
$$\mathbf{r}_3^T(\mathbf{P}_2 - \mathbf{P}_1) = 0$$
$$\mathbf{r}_1^T(\mathbf{P}_6 - \mathbf{P}_5) = 0$$
$$\mathbf{r}_3^T(\mathbf{P}_6 - \mathbf{P}_5) = 0$$

12. (Original) The linear method of claim 11, wherein components r1, r2 and r3 are computed as:

$$\mathbf{r}_3 = (\mathbf{P}_6 - \mathbf{P}_5) \times (\mathbf{P}_2 - \mathbf{P}_1),$$

$$\mathbf{r}_2 = \mathbf{r}_3 \times (\mathbf{P}_2 - \mathbf{P}_1)$$
$$\mathbf{r}_1 = \mathbf{r}_2 \times \mathbf{r}_3$$

13. (Original) The linear method of claim 12, wherein a motion of head points is represented according to $\mathbf{P}_i' = R\mathbf{P}_i + \mathbf{T}$ where $R = \begin{bmatrix} \mathbf{r}_1^T \\ \mathbf{r}_2^T \\ \mathbf{r}_3^T \end{bmatrix} = [r_{ij}]_{3\times 3}$ represents image rotation, $\mathbf{T} = [T_1 \quad T_2 \quad T_3]^T$ represents translation, and $\mathbf{P}_i'$ denotes a 3-D image position of four points P_k of another facial image

14. (Original) The linear method of claim 13, wherein

$$\begin{bmatrix} \mathbf{P}_i^T & \mathbf{0}^T & \mathbf{0}^T & 1 & 0 & 0 \\ \mathbf{0}^T & \mathbf{P}_i^T & \mathbf{0}^T & 0 & 1 & 0 \\ \mathbf{0}^T & \mathbf{0}^T & \mathbf{P}_i^T & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \mathbf{r}_1 \\ \mathbf{r}_2 \\ \mathbf{r}_3 \\ \mathbf{T} \end{bmatrix} = \mathbf{P}_i',$$

each point pair yielding 3 equations, whereby at least four point pairs are necessary to linearly solve for said rotation and translation.

15. (Original) The linear method of claim 14, further comprising the step of: decomposing said rotation matrix R using Singular Value Decomposition (SVD) to obtain a form $R = USV^T$.

16. (Original) The linear method of claim 15, further comprising the step of computing a new rotation matrix according to $R = UV^T$.

17. (Currently Amended) A program storage device readable by machine, tangible embodying a program of instructions executable by the machine to perform method steps for performing head motion estimation from facial feature data, the method comprising the steps of:

obtaining a first facial image and detecting a head in said first image;

detecting position of <u>not more than</u> four points P of said first facial image where $P = \{\mathbf{p}_1, \mathbf{p}_2, \mathbf{p}_3, \mathbf{p}_4\}$, and $\mathbf{p}_k = (x_k, y_k)$;

obtaining a second facial image and detecting a head in said second image;

detecting position of <u>not more than</u> four points P′ of said first facial image where $P' = \{\mathbf{p}'_1, \mathbf{p}'_2, \mathbf{p}'_3, \mathbf{p}'_4\}$ and $\mathbf{p}'_k = (x'_k, y'_k)\cancel{)}$; and,

determining the motion of the head represented by a rotation matrix R and translation vector T using said points P and P′.

18.(Original) The program storage device readable by machine as claimed in claim 17, wherein said four points P of said first facial image and four points P′ of said second facial image include locations of outer corners of each eye and mouth of each respective first and second facial image.

19.(Original) The program storage device readable by machine as claimed in claim 17, wherein said head motion estimation is governed according to:

$\mathbf{P}_i' = R\mathbf{P}_i + \mathbf{T}$, where $R = \begin{bmatrix} \mathbf{r}_1^T \\ \mathbf{r}_2^T \\ \mathbf{r}_3^T \end{bmatrix} = [r_{ij}]_{3\times3}$ and $\mathbf{T} = [T_1 \quad T_2 \quad T_3]^T$ represent camera rotation and translation respectively, said head pose estimation being a specific instance of head motion estimation.

20. (Currently Amended) ~~The~~ A program storage device readable by machine ~~as claimed in claim 19~~, tangible embodying a program of instructions executable by the machine to perform method steps for performing head motion estimation from facial feature data, the method comprising the steps of:

obtaining a first facial image and detecting a head in said first image;

detecting position of four points P of said first facial image where $P = \{\mathbf{P}_1, \mathbf{P}_2, \mathbf{P}_3, \mathbf{P}_4\}$, and $\mathbf{P}_k = (x_k, y_k)$;

obtaining a second facial image and detecting a head in said second image;

detecting position of four points P′ of said first facial image where $P' = \{\mathbf{p}_1', \mathbf{p}_2', \mathbf{p}_3', \mathbf{p}_4'\}$ and $\mathbf{p}_k' = (x_k', y_k')$; and

determining the motion of the head represented by a rotation matrix R and translation vector T using said points P and P',

wherein said head motion estimation is governed according to:

$\mathbf{P}_i' = R\mathbf{P}_i + \mathbf{T}$, where $R = \begin{bmatrix} \mathbf{r}_1^T \\ \mathbf{r}_2^T \\ \mathbf{r}_3^T \end{bmatrix} = \left[r_{ij}\right]_{3\times 3}$ and $\mathbf{T} = \left[T_1 \quad T_2 \quad T_3\right]^T$ represent camera rotation and translation respectively, said head pose estimation being a specific instance of head motion estimation, and

wherein said head pose estimation is governed according to said rotation matrix R, said method further comprising the steps of:

determining rotation matrix R that maps points $\mathbf{P}_k$ to $\mathbf{F}_k$ for characterizing a head pose, said points $\mathbf{F}_1, \mathbf{F}_2, \mathbf{F}_3, \mathbf{F}_4$ representing three-dimensional (3-D) coordinates of the respective four points of a reference, frontal view of said facial image–, and $\mathbf{P}_k$ is the three-dimensional (3-D) coordinates of an arbitrary point where $\mathbf{P}_i = [X_i \quad Y_i \quad Z_i]^T$, said mapping governed according to the relation:

$$R(\mathbf{P}_2 - \mathbf{P}_1) \propto \left[1 \quad 0 \quad 0\right]^T$$
$$R(\mathbf{P}_6 - \mathbf{P}_5) \propto \left[0 \quad 1 \quad 0\right]^T$$

wherein P_5 and P_6 are midpoints of respective line segments connecting points P_1P_2 and P_3P_4 and, line segment connecting points P_1P_2 is orthogonal to a line segment connecting points P_5P_6, and $\propto$ indicates a proportionality factor.

21. (New) The program storage device readable by machine as claimed in claim 20, wherein components r1, r2 and r3 are computed as:

$$
\begin{aligned}
\mathbf{r}_2^T(\mathbf{P}_2 - \mathbf{P}_1) &= 0 \\
\mathbf{r}_3^T(\mathbf{P}_2 - \mathbf{P}_1) &= 0 \\
\mathbf{r}_1^T(\mathbf{P}_6 - \mathbf{P}_5) &= 0 \\
\mathbf{r}_3^T(\mathbf{P}_6 - \mathbf{P}_5) &= 0
\end{aligned}
$$

22. (New) The program storage device readable by machine as claimed in claim 20, wherein components r1, r2 and r3 are computed as:

$$\mathbf{r}_3 = (\mathbf{P}_6 - \mathbf{P}_5) \times (\mathbf{P}_2 - \mathbf{P}_1),$$

$$
\begin{aligned}
\mathbf{r}_2 &= \mathbf{r}_3 \times (\mathbf{P}_2 - \mathbf{P}_1) \\
\mathbf{r}_1 &= \mathbf{r}_2 \times \mathbf{r}_3
\end{aligned}
$$

23. (New) The program storage device readable by machine as claimed in claim 20, wherein

$$\begin{bmatrix} \mathbf{P}_i^T & \mathbf{0}^T & \mathbf{0}^T & 1 & 0 & 0 \\ \mathbf{0}^T & \mathbf{P}_i^T & \mathbf{0}^T & 0 & 1 & 0 \\ \mathbf{0}^T & \mathbf{0}^T & \mathbf{P}_i^T & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \mathbf{r}_1 \\ \mathbf{r}_2 \\ \mathbf{r}_3 \\ \mathbf{T} \end{bmatrix} = \mathbf{P}_i' ,$$

each point pair yielding 3 equations, whereby at least four point pairs are necessary to linearly solve for said rotation and translation.

24. (New) The program storage device readable by machine as claimed in claim 23, further comprising the steps of decomposing said rotation matrix R using Singular Value Decomposition (SVD) to obtain a form $R = USV^T$.

25. (New) The program storage device readable by machine as claimed in claim 23, further comprising the steps of computing a new rotation matrix according to $R = UV^T$.